the resultants are most northerly at one station they are most southerly at the other and vice versa.

The remarkable relations revealed by these tables and charts show that the natural relations of the winds are complex and still obscure. I see no indication of a sun spot nor of a lunar influence. To what natural laws or combinations of laws are we to attribute these variations in the annual resultants?

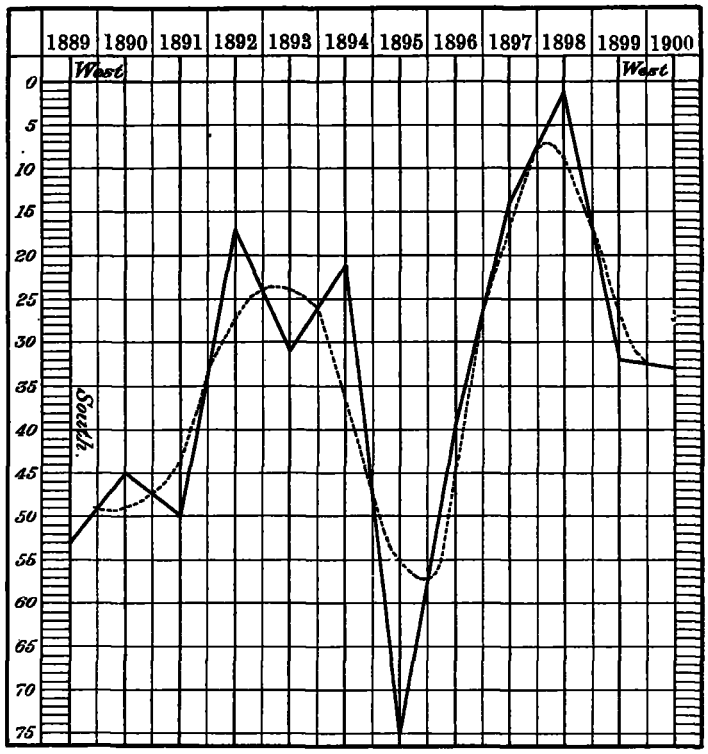


FIG. 3.—Resultants of all observations of winds at Bermuda.

TABLE 3.—*Ranges of annual resultants in the United States and Canada.*

| Station. | Annual oscillation, mean curve. | Variation of resultant from east or west. | | | | | Tendency of progression north or south. (See charts.) |
|---|---|---|---|---|---|---|---|
| | | Maximum degree and direction. | Year. | Minimum degree and direction. | Year. | Range. | |
| | | ° | | ° | | ° | |
| Bismarck, N. Dak. | Regular... | e. 41 n. | 1892 | w. 53 n. | 1895 | 78 | n. |
| Boston, Mass. | ....do ..... | w. 13 n. | 1896 | w. | 1894 | 13 | n. |
| Buffalo, N. Y. | Irregular . | w. 40 s. | 1891 | w. 8 s. | 1895 | 32 | n. |
| Chicago, Ill. | ....do ..... | w. 64 s. | 1891 | w. 5 n. | 1897 | 69 | s. |
| Cleveland, Ohio. | Regular... | w. 81 s. | 1895 | w. 45 s. | 1892 | 36 | s. |
| Cincinnati, Ohio. | ....do ..... | e. 68 s. | 1891 | w. 63 s. | 1897 | 49 | n. |
| Detroit, Mich. | ....do ..... | w. 30 s. | 1898 | w. 3 s. | 1891, 1895 | 27 | s. |
| Dodge, Kans. | Irregular . | w. 85 s. | 1897 | e. 7 s. | 1892 | 88 | s. |
| Eastport, Me. | ....do ..... | w. 20 s. | 1895 | w. 3 s. | 1898 | 30 | n. |
| Galveston, Tex. | Regular... | e. 61 s. | 1896 | e. 37 s. | 1900 | 24 | n. |
| Havre, Mont. | Irregular . | w. 22 n. | 1893 | w. | 1898 | 23 | s. |
| Kansas City, Mo. | ....do ..... | e. 86 s. | 1897 | e. | 1898 | 86 | n. |
| Key West, Fla. | ....do ..... | e. 26 n. | 1877 | e. | 1875, 1898 | 29 | |
| Marquette, Mich. | ....do ..... | w. 37 n. | 1892 | w. 14 n. | 1893, 1898 | 23 | s. |
| Memphis, Tenn. | ....do ..... | | | | | | |
| New Orleans, La. | ....do ..... | e. 53 s. | 1899 | e. 5 s. | 1894 | 80 | s. |
| New York, N. Y. | Regular... | w. 28 n. | 1899 | w. 4 s. | 1897 | 48 | n. |
| Philadelphia, Pa. | Irregular . | w. 39 n. | 1893 | w. 14 n. | 1894 | 25 | s. |
| Pittsburg, Pa. | ....do ..... | w. 30 n. | 1899 | w. 4 s. | 1894 | 55 | n. |
| Portland, Oreg. | ....do ..... | w. 44 s. | 1899 | w. 5 s. | 1895 | 58 | s. |
| St. Louis, Mo. | Regular... | w. 83 s. | 1897 | w. 9 s. | 1891 | 74 | s. |
| St. Paul, Minn. | ....do ..... | w. 72 s. | 1894 | w. 2 s. | 1898 | 70 | n. |
| Salt Lake City, Utah. | Irregular . | e. 86 s. | 1898 | e. 18 s. | 1893 | 68 | s. |
| San Diego, Cal. | Regular... | w. 33 n. | 1897 | w. 6 n. | 1892 | 27 | n. |
| San Francisco, Cal. | ....do ..... | w. 47 s. | 1894 | w. 2 s. | 1897 | 45 | n. |
| Santa Fe, N. Mex. | ....do ..... | e. 55 s. | 1899 | e. 19 s. | 1892 | 36 | s. |
| Savannah, Ga. | Irregular . | w. 84 s. | 1896 | w. 22 s. | 1900 | 62 | n. |
| Washington, D. C. | Regular... | w. 45 n. | 1897 | w. 10 s. | 1899 | 56 | s. |
| St. Johns, N. F. | Irregular . | w. 63 n. | 1892 | w. | 1900 | 67 | s. |
| Sydney, C. B. I. | ....do ..... | w. 39 s. | 1892 | w. 2 s. | 1898 | 47 | n. |
| Father Point, Que. | Regular... | w. 23 n. | 1892 | w. | 1898 | 78 | s. |
| Quebec, Que. | Irregular . | w. 46 n. | 1896 | w. 7 n. | 1895 | 39 | |
| Montreal, Que. | Regular... | w. 40 s. | 1891 | w. 4 n. | 1896 | 46 | s. |
| Toronto, Ont. | ....do ..... | w. 54 n. | 1898 | w. 4 n. | 1896 | 75 | n. |

The locations of the general areas of high and low pressure or the general trend of isobars at any time has a definite influence on the winds of that date; so, also, these resultants have some relation to the annual or normal isobars; but the outstanding discrepancies are still very great. The primary consideration in explaining these must be the permanent location and influence of the continents and oceans and the temporary influence of the areas of high and low pressure that move about just enough to justify their being known as subpermanent tropical areas. The effect of the diurnal land and sea breezes and the annual monsoon winds seems to be inappreciable.

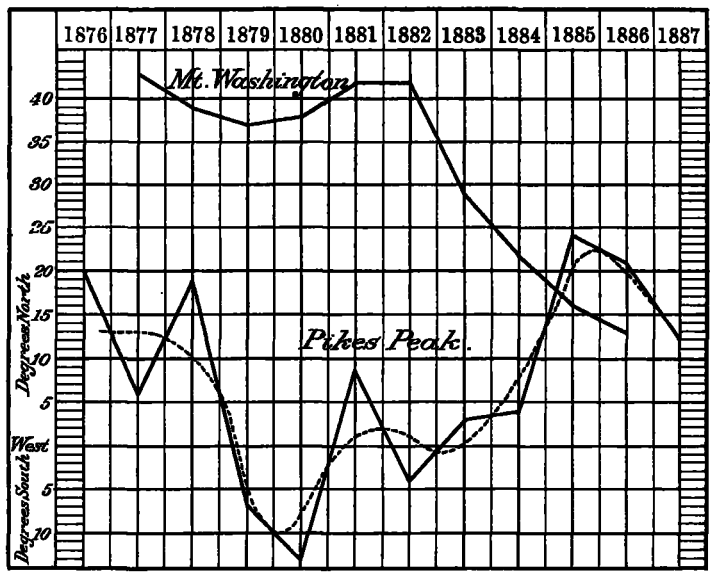


FIG. 4.—Resultants of all winds at Mount Washington and Pikes Peak.

TABLE 4.—*Key West resultants.*

| Year. | Direction from— | Year. | Direction from— | Year. | Direction from— |
|---|---|---|---|---|---|
| | ° | | ° | | ° |
| 1873 | e. 24 n. | 1883 | e. 7 n. | 1892 | e. 3 s.* |
| 1874 | e. 17 n. | 1884 | e. 5 n. | 1893 | e. 7 n.* |
| 1875 | east. | 1885 | e. 16 n. | 1894 | e. 4 n.* |
| 1876 | e. 1 n. | 1886 | e. 13 n. | 1895 | e. 11 n.* |
| 1877 | e. 26 n. | 1887 | e. 16 n. | 1896 | e. 9 n.* |
| 1878 | e. 21 n. | 1888 | e. 1 s. | 1897 | e. 5 n.* |
| 1879 | e. 4 n. | 1889 | e. 16 n. | 1898 | east.* |
| 1880 | e. 1 s | 1890 | e. 1 n. | 1899 | e. 12 n.* |
| 1881 | e. 13 n. | 1891 | *e. 8 n. | 1900 | e. 8 n.* |
| 1882 | e. 4 n. | | | | |

* The resultants for 1891–1900 are those deduced from the hourly observations.

## THE CLIMATOLOGY AND WATER POWER OF PORTO RICO.

By WM. H. ALEXANDER, Observer, Weather Bureau, dated December 29, 1902.

The climatology of Porto Rico is, in several respects, unknown and the island is therefore to some extent a new meteorological field. It is certainly a most inviting one to the student of tropical meteorology, as it presents in a small space many of the most interesting problems. It possesses a singularly peculiar topography which creates surprising local climatic differences. Analogous differences moreover characterize more or less the geological structure, the composition of the soil, the flora, and the hydrography of the island. For instance, the island, small as it is, has a range in the extremes of precipitation (that is, the difference between the amounts of greatest and least precipitation at different places) almost if not quite as great as is to be found in the whole of the United States. These differences are so pronounced and important that they can not be ignored when considering the agricultural possibilities and water resources of the island and must be taken into account in all problems relative to irriga-

tion and the construction of highways. Each locality has its own peculiarities and possibilities and must be studied independently in order to arrive at a safe working knowledge upon which to launch a new enterprise. General statements as to climate, soil, flora, and hydrographic conditions are often misleading and wholly inadequate for either business or scientific purposes, and the sooner exact data are available the sooner may we expect to see the development of the island go forward by the successful establishment of new enterprises.

In recognition of these peculiar conditions and in the hope of securing for and presenting to the public fuller and more exact information relative thereto, the Chief of the Weather Bureau has just authorized some special work in the collection of all information possible, both new and old, bearing on the climatology of the island and its relation to crops, hygiene, water power, commerce, and other matters of public interest. Introductory to this work, the results of which will be published later, and more especially to that part relative to the water resources of the island, it may be well to make a few observations in regard to its topography and rainfall.

In form, the island of Porto Rico is strikingly rectangular, the greater axis lying almost exactly east and west. The average width of the island is about 35 miles, and the average length about 105 miles. The area is, therefore, about 3,670 square miles. This, of course, is exclusive of the smaller dependent islands such as Vieques, Culebra, and others. The orography of the island constitutes its most striking and important characteristic. The mountains are not very high, but almost the entire surface of the island is covered with mountain peaks of varying heights and shapes, apparently without order or system as to arrangement. In places these mountains meet the sea with such abruptness that there is not room for even a driveway between mountain and sea, and in no place is there a marginal coast of considerable breadth. Notwithstanding this apparently confused and indiscriminate arrangement of the mountains, there is indeed a well-defined watershed dividing the island into two unequal portions. This divide extends from the southwest corner of the island eastward, closely parallel to the southern coast line and from 10 to 15 miles from it until within the vicinity of Guayama it approaches even nearer to the coast and then trends northeastward as does the coast line finally culminating in the highest peak on the island, El Yunque. This dividing ridge varies in height from 2,500 to 3,670 feet, and is made up of several sections, each having its own name. It will thus be evident that about one-third of the island is situated to the south of this divide and two-thirds to the north. The southern slope is necessarily very abrupt while the northern is more gradual. Both are broken up into innumerable hills and mountains with as many streams between, giving to the island a truly rugged aspect. It may help to a proper appreciation of the mountainous nature of the interior to know that there are in Porto Rico between 1,200 and 1,300 streams having names and of these about 30 are true rivers, many of them having magnificent waterfalls, especially those on the northern slope. Thus the island is divided hydrographically into two distinct sections: one lying to the east and south of the watershed, where the rivers are short and the velocity of their waters very great. The rivers of this section vary in length from 5 to 15 miles measured along their stream beds. The other section lies to the north and west of the divide and has longer rivers with larger basins. Here the rivers vary in length from 35 to 40 miles. These rivers are often very precipitous in their descent, especially for the first few miles below their sources where they frequently descend from 1,000 to 2,000 feet within less than 10 miles. Naturally, therefore, one would expect to find not a few magnificent waterfalls of great power and beauty. The possibilities of these falls as sources of power and for other purposes certainly merit a more thorough investigation than has heretofore been accorded them.

Porto Rico lies well within the northeast trade winds, which blow with great constancy throughout the year, and owing to the peculiar relation of the topography of the island to these winds, we find that the hydrographic divisions answer also for climatological purposes, the essential and determining causes being practically the same. Given, therefore, a thorough knowledge of the topography, one is at once in possession of a key to the peculiar distribution of the rainfall over the island. Under existing conditions, the east and north sides of the divide must receive by far the greater rainfall and the south and west sides the less. The records abundantly confirm the correctness of this statement. The heaviest rainfall in Porto Rico occurs in the neighborhood of Luquillo in the northeastern part of the island. There the annual fall amounts to about 150 inches. A fall of 100 inches or more at stations situated on or near the watershed is of common occurrence. Along the northern slope and especially near the coast the fall is much less, the average for a north coast station being about 55 inches. That portion of the island south and west of the divide receives still less rainfall. Not only so, but the fall seems to be more or less erratic, often resulting in severe droughts and rendering irrigation indispensable. It is thus seen that Porto Rico has wet and dry sides, more pronounced than its so-called "wet and dry seasons." The effect of this difference in the rainfall is at once seen by contrasting the truly tropical luxuriance of the vegetation on the north side with the barren hills and semiarid slopes on the south side. The dry stony river beds of the south side are also in marked contrast to the overflowing, bounding streams on the north side.

As above intimated, there exist in Porto Rico some interesting and seemingly valuable waterfalls. Among the best known and perhaps the most important, we may mention the following, viz;

Salto de Rio de la Plata, near Comerio; Salto Rio Blanco; Salto Morones, in Arecibo River, near Utuado; Salto Maldonado, in Arecibo River; Salto Sanchez, in Arecibo River; Salto Palmieri, in Arecibo river; and Salto Paso Palma, in Yayuya.

A franchise has just been granted for the development of the first-mentioned fall, the object being to utilize its power to operate a railroad from Catano to Ponce. Promoters are also investigating some of the other falls with a view to their development for electrical plants and other purposes. We hope soon to be able to present some details as to the size of the above-mentioned falls, their available power, and other information relative thereto of value to engineers and agriculturists.

## NOTES AND EXTRACTS.

### TROMHOLT'S CATALOGUE OF NORWEGIAN AURORAS.

No one has labored more faithfully to elucidate the problem of the aurora than Dr. Sophus Tromholt of Rostock, Norway, who died April 17, 1896.

Among his most important works was that done when he, in 1882–83, personally occupied a station at Koutokeino, in Finmark, Norway, in order to study the auroras observed by the Norwegian party at Bossekop, Norway, and the Finnish party at Sodan-Kyla. Tromholt was about 66 miles south of Bossekop, and 190 miles northwest of Sodan-Kyla, and observations of the auroras were made at all three stations at prearranged moments of time for the express purpose of determining their altitudes. The results of these special observations have as yet been only partially published.

In Petermann's Mittheilungen, 1892, Vol. XXXVIII, Tromholt published a preliminary report on two important works that he then had in hand, namely, a complete catalogue of the observations of auroras, as recorded by Norwegian ob-